sonable things. The gravest question of the time—one which affected seriously the moral welfare of forty millions of people, the honor of the nation before the world, the future of the country and the future of democracy—was settled scarcely more reasonably than if half a dozen paper slips had been put into a hat and shaken. It was a return to the foolish processes which made Presidents of Polk and Pierce. This plan indeed gave us Lincoln, and events have proved that the choice made at Cincinnati was a fortunate one, but fortune, and not the convention, is entitled to the credit of it. The convention's general manner of conducting business was unreasonable. It was certainly unreasonable if they considered themselves the responsible agents of the country. It was, perhaps, not so unreasonable if they were there merely to hurry through the job which would best suit themselves. A convention is supposed to be a deliberative body. There was indeed some deliberation, but it was altogether concerning unimportant matters. Not the least deliberation was permitted with regard to the great act for which the convention had been called together. There was not the least opportunity for an interchange of "views," in case any one present had any. Had any speaker wished to give his reasons why it would be more difficult than at any previous time for the party to carry the election, and therefore why a certain course of action should be pursued, there would have been no opportunity to give them. Had there been such an opportunity, I doubt if any one would have dared to say such things. He would have made the convention angry, and the minority to which he belonged would have considered him a marplot and a busybody. No one seemed to represent himself. The convention was, of course, a very powerful body; it could well afford to smile in contempt upon opinions such as these, but these opinions are nevertheless true, and he can have little hope of his country who does not expect them to prevail.

JOHN ERICSSON.

By the roadside in a mountain hamlet near the iron-works of Langbanshyttan, Central Sweden, stands a pyramid of iron cast from ore dug from the adjacent mines and set upon a base of granite quarried from the hills which overlook the valley. Upon the face of this monument appears this legend:

IN A MINER'S HUT AT LANGBANSHYTTAN WERE BORN THE TWO BROTHERS

NILS ERICSSON, JANUARY 31ST, 1802,

AND

JOHN ERICSSON, JULY 31ST, 1803,

BOTH OF WHOM HAVE SERVED AND HONORED THEIR NATIVE LAND.

THEIR WAY THROUGH WORK TO KNOWLEDGE AND LASTING FAME IS OPEN FOR EVERY SWEDISH YOUTH.

The monument is placed at the turn of the road which leads to the village school-house, and, as if to point the "Swedish youth" to the first step in his progress toward "knowledge and lasting fame," it bears upon its reverse side this inscription:

THE WAY TO THE SCHOOL-HOUSE OF LANGBANSHYTTAN.

Nils Ericsson was a man of unusual ability, and deservedly held high position in Sweden as engineer of the canals and railroads of the kingdom, but his reputation is a local one; the name of his brother is familiar to all who have any knowledge of the progress of engineering science during the past half century. The two brothers were sons of Olof Ericsson, a Swedish miner. What is known of him and his wife, the mother of Nils and John, shows that the Ericssons come of no ordinary stock. The father-in-law of Olof was a man of property, but the transmitted property went no further, disappearing in unfortunate investments in silver mines. Thus it happened that to the grandsons fell the fortunate inheritance of poverty, and among John's earliest recollections is that of the seizure of the household effects by the remorseless hands of the sheriff. This occurred when he was five years of age. The wife of Olof was a woman of intelligence and refined tastes, and was intimately acquainted with the light literature of the time.

The early years of John Ericsson were spent among the hardy and industrious people who bring forth from the mines of Nordmark, Taberg, Persberg, and Langban more than one-fifth of the iron ore mined in Sweden. These iron mines are situated in the beautiful province of Wermland, in Central Sweden, midway between the capitals of the sister kingdoms of Sweden and Norway. In one of the many valleys formed by the sloping mountains of this beautiful region, John Ericsson was born. The inspiration of his genius was found, however, not in the varied scenery of its rocky forests and its glistening lakes, but in the hard, practical life of a people who hide themselves away from the sunlight that they may do their appropriate work in an age of iron and steam. Among the earliest sounds that greeted his ears was the clash of the rude machinery with which the miners worked; among his earliest playthings were miniature machines and tools of his own contrivance. Before he was eleven years old, during the winter of 1813, John had produced a saw-mill of ingenious construction, and had planned a pumping engine designed to clear the mines of water. The frame of the saw-mill was of wood; the saw-blade was made from a watch-spring, and the crank which actuated it was cast from a broken tin spoon. A file, borrowed from a neighboring blacksmith, to cut the saw-teeth, a gimlet, and the ubiquitous jack-knife, were the only tools available for this work.

A much more ambitious undertaking was the pumping engine. The year before, when only nine years of age, young Ericsson had made the acquaintance of drawing instruments in one of the draught offices of the grand ship canal of Sweden, and learned how these instruments were used to lay out the work of construction in advance. Meanwhile, his father had removed to the depths of a pine forest where he selected the timber for the lock-gates of the canal. In this wilderness, a quill and a pencil were the boy's utmost resources in the way of drawing tools. Like Crusoe on his island, he had to begin at the beginning. He made compasses of birch-wood with needles inserted in the ends of the legs. A pair of steel tweezers, obtained from his mother's dressing-case, were converted into a drawing pen, and the same good mother was persuaded, after much entreaty, to allow her sable cloak to be robbed of hair enough to provide material for two small brushes with which to apply the coloring at that time deemed essential in all mechanical drawings. The pumping engine was to be operated by a wind-mill, and here the youthful inventor was at fault. He had heard much about a wind-mill but had never seen one. Following, as well as he could, the description of those who had had the happiness to view this wonderful machine, he succeeded in constructing on paper the mechanism connecting the crank of the wind-mill shaft with the pump levers, but how to turn the mill to the changing wind he could not divine. Fortunately, John's father made a visit to the wind-mill, and, in describing what he had seen, spoke of a "ball and socket joint." The hint was sufficient; the boy rushed to his drawing table and had soon added a ball and socket joint where the connecting-rod for the driving crank joined the pump lever. With the execution of this drawing began John Ericsson's mechanical career. The plan conceived and executed under such discouraging circumstances by a mere child attracted the attention of Admiral Count Platen, the President of the Gotha Ship Canal, on which Ericsson's father was employed, and one of Sweden's great men. "Continue as you have begun and you will one day produce something extraordinary," prophesied the count of his young *protégé*. Richly has the prophecy been fulfilled.

Ericsson was appointed a cadet in the Swedish corps of mechanical engineers when he was twelve years old, was soon after promoted to *nivelleur* (leveler), and at the age of thirteen was put in charge of a section of the ship canal over which his friend, the count, presided. Six hundred of the royal troops, at work upon this section, looked for directions in their daily work to this child, among whose necessary attendants was one who followed after him with the stool upon which he stood to raise himself to the height of his leveling instruments. The amusements of this boy-engineer are indicated by his possession at the age of fifteen of a portfolio of drawings, made in his leisure moments, giving maps of the most important parts of the grand canal, three hundred miles in length, and showing all the machinery and implements used in its construction. Many important works upon this canal, which opens an inland channel across Sweden from the Baltic to the North Sea, were constructed from drawings made by Ericsson at an age when he might rather have been expected to be found playing foot-ball.

His precocity was not due to any forcing process: it was the normal and healthy development of a mind with which the comprehension of mechanical principles is as instinctive as the perception of the harmonies of color and form to Raphael, or those of musical expression to Beethoven. This quality of Ericsson's mind is shown by the fact that, when a little later on, he was required to pass an examination in geometry, it was discovered that he was so complete a master of geometrical principles, that he could, without having seen them, repeat all correctly written demonstrations of the textbooks.

It is in this instinctive quality of his mind that we find, not only the secret of the extraordinary success that has attended Ericsson's career of over sixty years as an engineer, but the explanation of many of the difficulties with which he has contended through life. His own mind reaches its conclusions by processes which make him utterly impatient of the slower methods of others; and it has been upon others, and they in authority, that he has had to depend for the opportunity to work out his engineering conceptions; conceptions which have associated his name with more great and revolutionary changes in the departments of naval and mechanical engineering, than are to be ascribed to any other living man. Indeed, Ericsson is so removed from his fellows by the very singularity of his genius for mechanics, that few are aware that he is at the head of his profession—a position to which his works justly entitle him. Though he has given abundant evidence of his ability to influence men, when he seeks to do so, he has succeeded by pure force of intellect and never by courting the arts of popularity. He seeks no one, and those who cannot come to him must be content to pass him by, for no king demands more implicit acquiescence in his authority than he does in the authority of his engineering dicta. Are lesser men slow to perceive, his spirit is not that of the school-master, patient in elucidation, and he leaves them to their ignorance. He has not been, therefore, an easy man for boards and authorities to deal with. They would rather any other man than Ericsson should be the author of the revolutionary ideas he forces them to adopt; and the brains which are large enough to comprehend his ideas in the beginning are few.

It has been his mission in more than one instance to outrage all precedent, to violate all doctrine, and especially in the department of naval warfare, to compel a complete reversal of existing methods. He obliged naval officers to descend from the dignity of their quarter-decks, and go to sea "in a cheese box on a raft"; he persisted in making the propeller a success when the entire board of the British Admiralty, First Lord and all, had demonstrated that it would be impossible to steer a vessel propelled by a screw applied at the stern. He has been the Jonah, crying through the streets of the great city of existing establishments, "Yet forty days and Nineveh shall be overthrown." We doubt not that those whose peace he has disturbed have wished him where Jonah was—in the whale's belly.

Captain Ericsson has lived to be nearly seventy-six years of age; but for this fortunate longevity he could not have witnessed the success of his chief inventions. When he had already passed his half century, his "new system of naval warfare" was first presented to the Emperor Napoleon III. in a letter dated New York, Sept. 26, 1854, and it was not until 1862 that the encounter between the *Monitor* and the *Merrimack* in Hampton Roads compelled the navies of the world to adopt one of the leading features of this system which so shocked conservatism. Some of its suggestions are yet awaiting recognition; but its author's career is not yet ended. Sixty-four years have passed since he entered the service of Bernadotte, afterward King Charles John XIV. of Sweden, and this two-thirds of a century has been full of labor and of accomplishment: yet this man, who "by reason of strength" has reached those years which should be "labor and sorrow," asks no odds of younger men. He is still able to devote to his professional work twelve hours a day and that for three hundred and sixty-five days in the year.

It was in 1811, the year that Bernadotte became regent of Sweden, that Ericsson made the first scale drawing at the drawing office of the Gotha Ship Canal. In 1815 he made the drawing of the famous Sunderland iron bridge, which his friend Count Platen for years after delighted in showing to visitors. His occupation during the last twenty years has been chiefly sedentary; that he continues able to do as much work at the drawing board as any man, young or old, is due to the fact that he has, for the last thirty-six years of his life certainly, been absolutely faithful to the same correct rules of living which prolonged Bryant's capacity for work to his eighty-fourth year. Like Bryant, as described by his friend Bigelow, his health responds so faithfully to his inexorable loyalty to the principles he has adopted, as to go very far toward justifying Buffon's theory that "the normal life of man is a hundred years, and that it is due, not to the use but the abuse of his organization if he finds an earlier grave."

Ericsson's career in his native Sweden, though brief, was brilliant. From the position of an engineer upon the Gotha Canal he passed to that of an officer in the army of Sweden, whence comes his title of "Captain." The men under the charge of the young *nivelleur* were soldiers, and the work on the canal was in control of officers of the army, with whom he was brought into daily association. The natural result followed: the young engineer aspired to be a soldier. In spite of the indignant protests of Count Platen, who seems to have understood his genius better than the headstrong youth himself, Ericsson entered the military service as ensign, possibly intending to thus fulfill the parting injunction of the count to "go to the devil." Promotion to a lieutenancy speedily followed; the skill displayed in a map presented to the king as a specimen of Ericsson's ability having secured the reconsideration of an appointment which had been rejected because of the temporary disgrace of the officer recommending it, Colonel Baron Koskull. The appointments of government surveyors being offered soon after to competitive examination among the officers of the army, Ericsson hastened to Stockholm from his station in the northern highlands and entered the lists. As might be expected, after his experience upon the canal, he easily bore away a prize from the examination. Detailed maps of fifty square miles of Swedish territory, still on file at Stockholm, attest his skill and industry in this new employment. Though his work as a surveyor exceeded that of any of his fellows, his energies were not satisfied. He sought an outlet for his superfluous activity in preparing the drawings and engraving the sixty-four large plates for a work illustrating the Gotha Canal. Here his facility of invention was shown by the construction of a machine engraver, with which eighteen copper plates, each of 300 superficial inches, were completed by his own hand within a year. The work stopped with these. The principal reason for not completing the remaining forty-eight plates, which had been purchased, was the important fact that, so rapidly did mechanical improvements succeed each other at that particular period that before the work could have been finished, many plates would have proved worthless.

From engraving, young Ericsson turned his attention to experiments with flame as a means of developing mechanical power. The interest in these experiments shown by his immediate superior in the army, and the encouragement received from him, led to the invention of a flame engine. One was built which worked up to ten horse power. Its success turned Ericsson's thoughts in a new direction, and he obtained leave of absence to visit England, where he sought a larger field for the introduction of his invention. *En route* to London, he spent a week at Stockholm and participated in the festivities that attended the birth, May 3d, 1826, of a prince, afterward Charles XV. of Sweden and Norway. Once in England, he remained there. His resignation from the army was accepted after some delay, but most reluctantly, and not until he had received his promotion to captain.

Though Ericsson has never returned to his native country it has always retained the first place in his affection and has received substantial tokens of his regard. The motive machinery of the first fifteen-inch Swedish gun-boat was, for example, built by Ericsson at his own cost and presented by him to the Swedish Government as the model for the machinery of a fleet of gun-boats of a novel design, to be maneuvered by hand independently of steam, and carrying stationary turrets. Sweden in her turn has delighted to honor her distinguished son. Various Swedish orders and decorations have been conferred upon him and, besides the monument to the brothers Ericsson referred to above, a special one was erected in 1867 in honor of John Ericsson alone. This monument is a simple granite shaft, eighteen feet high, standing directly in front of the miner's cottage once occupied by Olof Ericsson. It bears this inscription in golden letters:

JOHN ERICSSON
WAS BORN HERE IN 1803.

On the day of its dedication, Tuesday, September 3d, 1867, work was suspended in the mines and iron furnaces, and from all directions the workmen gathered around the house in which John Ericsson first saw the light, the cottage now occupied by the inspector of the local mines. The lakes swarmed with row-boats crowded with passengers; the pathways were filled with foot travelers and the steamers abandoned their customary work of towing coal barges and carried peasants in their holiday garb to celebrate the "gala-day of the Swedish miner's son," famous in two hemispheres.

The band of the "Philipstad Volunteer Riflemen" played the familiar Wermland air of *Hell dig du höga Nord!* (Hail to thee, thou high North!) The volunteer riflemen blazed with their muskets, and the earth quaked with a subterranean explosion in the Langban mine as the veil fell from the monument, wreathed with garlands of *Erica vulgaris* in full bloom. "Our famous poet, A. A. Afzelius," described "the light fairies protectingly hovering above the cradle of the infant John, and Verdandi, Scandinavia's fair and gracious Norna, born in Valhalla," spinning silk and gold about it. The chief engineer of the mining district, A. Sjögren, from a tribune adorned with flowers delivered the dedication address, and a dinner followed with speeches from persons more accustomed than Mr. Sjögren to large audiences. Dr. Pallin from Philipstad, who proposed the health of John Ericsson, reminded his hearers that seven cities in Greece contended for the honor of being Homer's birth-place. "In those times," said Dr. Pallin, "parish register and certificate of baptism did not exist as at present. We are, of course, enabled to do our work more surely; yet to guard against all accidents we have here placed a record of baptism in behalf of John Ericsson, weighing 80,000 pounds, which cannot easily be rubbed out."

The monument stands on an isthmus between two lakes where it looks out on one side to the bluish mountains, casting their shadows in the waters, and on the other side over a fine cultivated valley surrounded by green hills.

Transferred to England in 1826, Ericsson carried thither little besides his inventive brain, his youthful enthusiasm and determined purpose, and a capacity for work which was in itself genius. Fortune did not attend his efforts to introduce his flame engine; the sea-coal of England was a very different fuel from the pine shavings with which the flame engine had hitherto been fed, and it did not take kindly to its new diet. The coal produced so intense a heat as to burn out its viscera, so to speak: that is, to destroy its working parts. An entirely new series of experiments had to be undertaken. They resulted finally in the completion of an engine which was patented and sold to John Braithwaite. Further experiments, requiring time and money, were needed and some means had to be sought for turning the young engineer's abilities to more speedy account. The records of the London Patent Office show how rapidly his inventions succeeded each other, and a list of his engineering works during the thirteen years he spent in England, bears testimony to his achievements. Among these works were a pumping engine on a new principle; engines with surface condensers and no smoke-stack, blowers supplying the draught, applied to the steamship *Victory* in 1828; and an engine consisting of a hollow drum which was rotated by the admission of steam, and continued to rotate for some hours after shutting off the steam, at the rate of 900 feet per second at the circumference, or the speed of London moving around the axis of the globe. Apparatus for making salt from brine; mechanism for propelling boats on canals; a variety of motors actuated by steam or hot air; a hydrostatic weighing machine to which the Society of Arts awarded a prize; an instrument now in extensive use for taking soundings independently of the length of the lead line; a file-cutting machine, and various others, are included in this list to the extent of some fourteen patented inventions and forty machines, all novel in design.

On board the *Victory*, the principle of condensing steam and returning the fresh water to the boiler, was first practically applied to navigation, and in the steam vessel *Corsair*, built at Liverpool in 1832, first appeared the centrifugal fan blowers now in use in most of the steam vessels in the United States. In a steam-engine erected on the Regent's Canal Basin in 1834 by Ericsson, steam was first super-heated, and in the *King William* and *Adelaide*, locomotives, 1830, the link motion for reversing steam-engines was first used, the so-called Stevenson link being a modification of this, the original link motion.

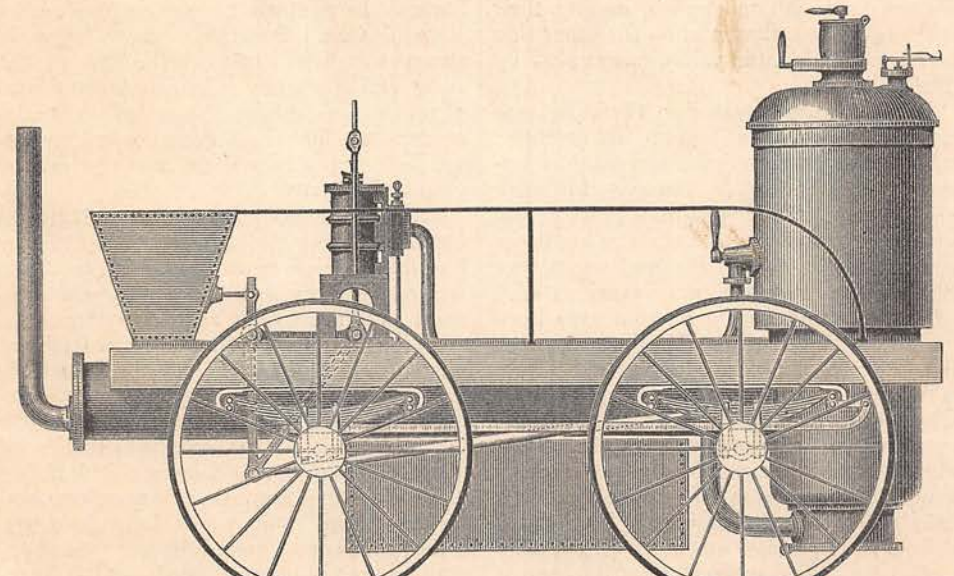
Besides all these, Ericsson at this period first introduced into a locomotive built by him the principle of artificial draft, to which we are primarily indebted for the development of our modern railway system. In 1829 the Liverpool and Manchester Railroad offered a prize of £500 for the best locomotive capable of fulfilling certain stipulations. It is well known that this prize was taken by Robert Stephenson with the *Rocket* planned by his father George; it is not so well known that Stephenson's sharpest competitor in this contest was John Ericsson. Four locomotives entered the contest, and according to the London "Times" of fifty years ago—October 8th, 1829—the speed of the others "was far exceeded by that of Messrs.

Braithwaite and Ericsson's beautiful engine from London,"—the *Novelty*. This was John Braithwaite, to whose pecuniary assistance Ericsson was greatly indebted in bringing out his inventions at this period. The "Times" continues: "It was the lightest and most elegant carriage on the road yesterday, and the velocity with which it moved surprised and amazed every beholder. It shot along the line at the amazing rate of *thirty* miles an hour. It seemed indeed to fly, presenting one of the most sublime spectacles of human ingenuity and human daring the world ever beheld."

The "Times" might well expend its rhetoric on the *Novelty*. On the issue of that trial turned the future of the railroad system of England. The railroad directors asked for only ten miles an hour; Ericsson gave them thirty. Astonishment for the moment silenced the multitude who watched the experiment, and then their excitement found vent in wild hurrahs. Within an hour, the shares of the Liverpool and Manchester Railroad leaped up ten per cent., and the young engineer might well have considered his fortune made. But disappointment awaited him, although he had beaten his rival ten miles an hour. In spite of much adverse criticism, the judges determined to make traction power, rather than speed, the critical test, and the prize was awarded to Stephenson's *Rocket*, which drew seventeen tons for seventy miles, at the rate of 13½ *miles an hour*. Stephenson's engine weighed 4 tons 3 cwt., Ericsson's but 2 tons 15 cwt. Ericsson was not aware that a prize had been offered by the directors of the Liverpool and Manchester Railway until seven weeks before the day of trial; but the *Novelty* was promptly on the ground on the appointed day. In this brief time all the plans of the unique machine had been made and the work executed,—a feat probably never surpassed, and rendered more remarkable as the structure was pronounced superior in point of finish and proportion to all the competing engines. It is not true, as has been asserted, that the *Novelty* broke down, the only accident that occurred being the splitting of a leather diaphragm of the blowing machine, and the giving out of some pipe joints, which were readily screwed up.

As to the principle of artificial draught, Ericsson was undoubtedly the first to demonstrate the fallacy of the accepted doctrine that a certain extent of surface exposed to fire was necessary for the generation of a given quantity of steam.

The compactness of construction which followed this demonstration led to the employment of steam in ways not before deemed possible; as for example in the steam fire-engine, with which Ericsson astonished London upon the occasion of the burning of the Argyle Rooms in 1829,



LOCOMOTIVE ENGINE "NOVELTY," CONSTRUCTED 1829.

"when for the first time fire was extinguished by the mechanical power of fire." A larger engine of costly workmanship, built for the King of Prussia, by Ericsson and Braithwaite, soon after rendered important service in saving valuable buildings at a fire in Berlin. A third was built for the Liverpool Docks in 1830. In January, 1840, the Mechanic's Institute of New York offered its great gold medal for the best plan of a steam fire-engine, and the prize was awarded to John Ericsson.

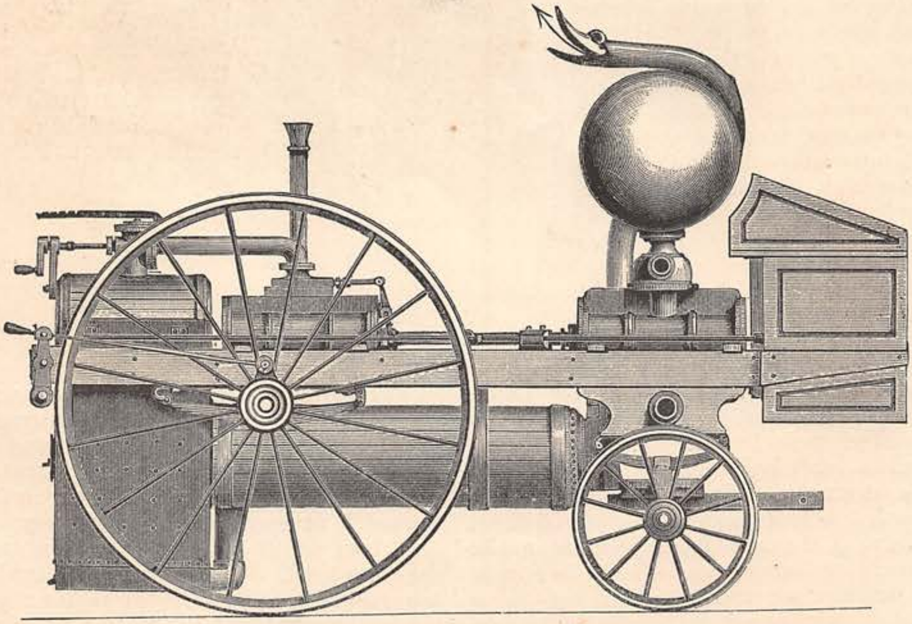
In 1833, Ericsson first brought to public notice his caloric engine. In this he sought to develop the theory which has given principal direction to the studies of his lifetime, viz.: that heat is an agent which undergoes no change, and that only a small portion of it disappears in exerting the mechanical force developed by our steam-engines. The working model of a caloric engine of five-horse power speedily attracted the attention of scientific London. Sir Richard Phillips, author of the "Dictionary of the Arts of Life and of Civilization," Dr. Andrew Ure, Professor Faraday, and others of like authority, at first gave it their approval. Brunel, the engineer and constructor of the abortive Thames Tunnel, visited the caloric engine with the English Secretary of the Home Department. He set his face against it at once, and a controversy with him, into which Ericsson was necessarily drawn, intensified this prejudice. Faraday, who had been announced to deliver a lecture on the new motor, in the theater of the Royal Institution, disappointed both his audience and the inventor by his inability at the last moment to explain the engine. Practical difficulties, relating to durability, in

JOHN ERICSSON.

the meantime developed themselves, and the invention was laid aside, after one farther attempt in an engine of larger size. The endeavor to perfect this motive power was renewed when Ericsson removed to this country in 1839. Several caloric engines were built in succession, each larger than the other. Finally, an experimental engine was produced in 1851, which seemed to be a solution of the problem, and the caloric ship *Ericsson*, a vessel of 260 feet in length, was built at great expense. The result of the experiment is best told in Ericsson's own words: "The ship after completion made a successful trip from New York to Washington and back, during the winter season; but the average speed at sea proving insufficient for commercial purposes, the owners, with regret, acceded to my proposition to remove the costly machinery, although it had proved perfect as a mechanical combination. The resources of modern engineering having been exhausted in producing the motors of the caloric ship, the important question has forever been set at rest, can heated air, as a mechanical motor, compete on a large scale with steam? The commercial world is indebted to American enterprise—to New York enterprise—for having settled a question of such vital importance. The marine engineer has thus been encouraged to renew his efforts to perfect the steam-engine without fear of rivalry from a motor depending on the dilation of atmospheric air by heat."

Although Ericsson thus gracefully withdrew this invention from the field of marine engineering, it does not follow that he abandoned it altogether. On the contrary, for the production of a small amount of power under special circumstances, the caloric engine has proved of great service. Improvements in the steam-engine have diminished its value, but it is still indispensable where water cannot be obtained; as for instance in generating the power needed in several of our light-houses. The thirty years of attention devoted to this engine has not been without purpose, and its designer has the credit of succeeding in large measure, in a field where many other experimenters have failed entirely, so far as producing practical results is concerned. At its annual meeting, June 10, 1862, the American Academy of Arts and Sciences passed this vote:

"Voted, that the Rumford premium be awarded to John Ericsson for his improvements in the management of heat, particularly as shown in his caloric engine of 1858."



STEAM FIRE-ENGINE, DESIGNED 1840.

Gold and silver medals were prepared in accordance with the statutes of the Academy and presented by Professor Horsford, this being the second occasion on which the Rumford medal has been bestowed in this country; the first medal having been given to Robert Hare for his invention of the oxyhydrogen blow-pipe.

No man has accomplished more with steam than Ericsson; yet he has never altogether abandoned his early idea of employing heat directly as a means of generating mechanical power. The flame engine is among the curiosities of the past; the caloric engine, though a mechanical success, —over 3,000 of them having been built—has not accomplished all that was intended. From the attempts to find a substitute for, or an auxiliary of, steam, in heat artificially produced, Ericsson has turned his attention to the problem of making direct use of the enormous dynamic force stored up in the sun's rays. Not that he expects or intends to supplant steam within its natural domain where the solar energy gathered during the carboniferous period is available for use; but over a large portion of the earth's surface the use of steam is impossible, neither fuel nor water being obtainable. It is in precisely this region that the radiant heat of the sun is the most intense and constant. Now, this heat is wasted, neither producing nor sustaining life, converting what might be some of the fairest portions of the earth's surface into desolate wastes.

"There is a rainless region," says Ericsson, "extending from the north-western coast of Africa to Mongolia, 9,000 miles in length, and nearly 1,000 miles wide. Besides the North African deserts, this region includes the southern coast of the Mediterranean, east of the gulf of Cabes, Upper Egypt, the eastern and part of the western coast of the Red Sea, part of Syria, the eastern part of the countries watered by the Euphrates and Tigris, Eastern Arabia, the greater part of Persia, the extreme western part of China, Thibet, and lastly, Mongolia. In the western hemisphere, Lower California, the table-land of Mexico and Guatemala, and the west coast of South America, for a distance of more than 2,000 miles, suffer from continuous radiant heat."

To make the enormous, and as yet unused, dynamic force of this radiant heat available for man's use is the problem to which Ericsson is principally devoting the

LOCKS OF THE GRAND SHIP CANAL OF SWEDEN.

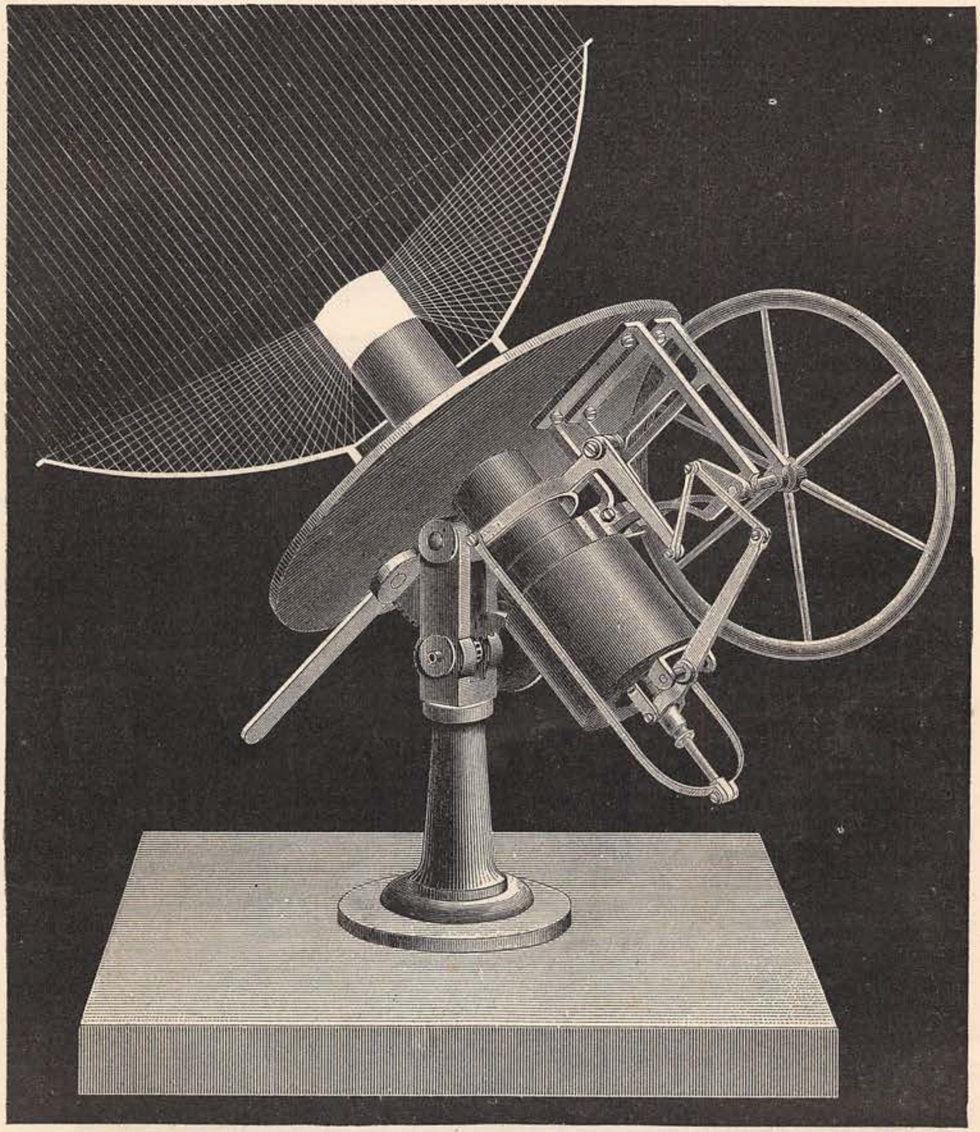
remaining years of his long and useful life. It is in a lofty spirit that he has approached the solution of this great problem. An inventor of less noble instincts might well have his imagination fired by the prospect of adding so enormously to the sum of human capacity, until the idea of mere personal advantage should lose itself in the grander one of public benefaction. Ericsson has resolved in advance that he will make use of the laws for the protection of inventors only to secure to the public what he intends to offer as his free gift to the race. It is a gift for the future, for, as we have said, he does not imagine that his invention can be made available in competition with machinery using wood and coal. But where or when artificial fuel is not to be obtained his solar engine will, he believes, open new possibilities to human achievement. To any one who will pay the price, he is prepared even now to furnish a solar engine of one hundred horse power. But the apparatus required to gather and concentrate the sun's radiant heat is too expensive to make the engine an economical one, and new conditions must arise before it will be required. Yet the solar engine is, its designer declares, a mechanical success and it needs only such a combination of wood and metal as he shall suggest to make at least possible such a transformation of the now waste portions of the earth's surface that the prophecy shall be fulfilled, and "the desert shall rejoice and blossom as the rose." The work of training the forces of nature to man's service is to continue until the sun, from whose dread presence he now hides himself away, shall become the slave to till his fields and transform into a fruitful garden "the plain which from its bed rejecteth every plant;" propelling for him the machinery which is to introduce a new, and it may be an even more varied and complex, civilization than we have yet seen, combining the warm fancy of the East with the practical accomplishment of the West. We are merely to follow Emerson's advice to "hitch our wagon to the stars," and Ericsson is to be the Vulcan who is to forge the coupling.

An important computation is made by Ericsson of the mechanical power that would result from utilizing the solar heat on a strip of land a single mile in width along the rainless western coast of America, the southern coast of the Mediterranean, the Nile, the Tigris and Euphrates, the Persian Gulf and the Red Sea,—an aggregate length of land far exceeding 8,000 miles, accessible by water communication. Such a strip, 8,000 miles in length and one mile wide, covers 223,000,000,000 of square feet. As it has been practically established that one hundred square feet will suffice to produce one horse power by the sun's radiant heat, we learn that over 22,000,000 solar engines equal to 100 horse power could be kept in operation nine hours a day by utilizing only the heat now wasted on the assumed small fraction of land extending along some of the water-fronts of the sunburnt regions of the earth.

"Due consideration," it is added, "cannot fail to convince us that the rapid exhaustion of the European coal-fields will soon cause great changes with reference to international relations, in favor of those countries which are in possession of continuous sun-power. Upper Egypt, for instance, will, in the course of a few centuries, derive signal advantage and attain a high political position on account of her perpetual sunshine and the consequent command of unlimited motive force. The time will come when Europe must stop her mills for want of coal. Upper Egypt then, with her unceasing sun-power, will invite the European manufacturer to remove his machinery and erect his mills on the firm ground along the sides of the alluvial plain of the Nile, where an amount of motive power may be obtained many times greater than that now employed by all the manufactories of Europe."

The invention of the solar engine is only an incident of the thorough investigation into the constitution of the sun, to which Ericsson has devoted years of his later life. In this investigation, his unbounded experience as a mechanical constructor has enabled him readily to design the apparatus required for his investigations and experiments, nearly all of which is novel. To begin with, the ordinary thermometer is useless for observations on solar heat. Mercury transmits heat from particle to particle too slowly to give a sufficiently rapid indication; and while one-half of the bulb of the thermometer is exposed to the sun's rays and receives heat from them, the other half in the shade, radiates this heat into space. For the mercury thermometer Ericsson has substituted the "barometric actinometer," in which heat is measured by the expansion of air in a bulb inclosed in a receiver from which the air is exhausted. With this instrument the sun's altitude and the intensity of its radiant heat can be observed simultaneously. Meteorologists will do well, we are told, "to adopt such an instrument in all important observations, since its simultaneous indications of solar intensity and zenith distance enable them to determine the relative amount of vapor present in the atmosphere with a degree of precision probably unattainable by any other means." Again, the accepted theories as to the reflective power of metals had to be set aside and an entirely new series of experiments has re-arranged the metals as follows, in the order of their power to reflect radiant heat: silver 1.000, brass .885, nickel .786, steel .709. On the authority of Laprovostaye and Desains, physicists who followed the thermo-electric method which Ericsson rejects, the relation of silver to brass is given as 1.000 to .978.

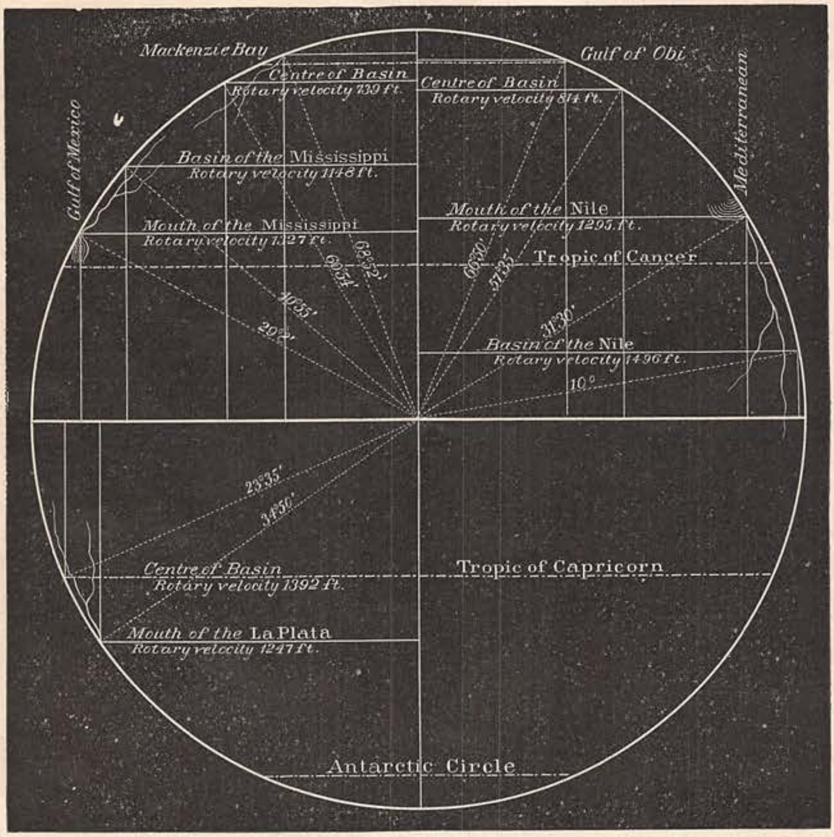
These are only illustrations, for it would



SOLAR ENGINE ACTUATED BY ATMOSPHERIC AIR WITHOUT THE INTERVENTION OF STEAM.

require a separate article to even indicate the results at which Ericsson has arrived, or to describe the novel methods of investigation pursued by him. He has demonstrated, among other things, that the polar and equatorial regions of the solar disk transmit radiant heat of equal intensity to the earth and that the sun emits heat of equal energy in all directions. Secchi attempted to dispute the accuracy of Ericsson's investigations of the intensity transmitted to the earth from various points of the solar disk, but he signally failed, as the readers of "Nature" are aware. The instrument constructed by Ericsson to solve the problem which the Italian astronomer had in vain grappled with for twenty years, is probably one of the most remarkable known to physical science.

In connection with his study of solar heat Ericsson has made some remarkable computations of the influences at work tending to retard the rotary motion of the earth. "That the hand and intellect of man," he says, "have caused a disturbance of the earth's center of gyration will be deemed a startling assertion, yet it cannot be controverted in view of the following facts. The millions of tons of matter contained in the pyramids, removed to a greater distance from the axis of rotation by the muscular exertion of the ancient Egyptians, disturbed the previous balance of the rotating mass, causing a tendency to check the earth's rotary velocity and to increase the length of day. Nor can it be questioned that if London had not been built, and if the building materials of Paris yet remained in the catacombs, the transfer of matter under consideration. A first-class modern city contains upward of a hundred thousand houses; each house contains on an average four hundred tons of mineral matter; hence the total weight of brick, earth or stone, removed from below the surface, exceeds forty million tons,—a mere fraction compared with the weight of the whole of human habitations and other structures raised above the surface of the earth, chiefly by muscular effort. Let us add the weight of material raised from mines



GEOMETRICAL REPRESENTATION OF THE EARTH FOR DETERMINING THE EFFECT PRODUCED ON ITS AXIAL ROTATION BY PRECIPITATION AND THE FLOW OF RIVER WATER.

sun would rise earlier than it now does, though the difference would be small beyond computation. The aggregate of the weight removed from below, and piled above the crust of the globe by the hand of man, is, however, so great that figures are competent to express the extent of the consequent retardation of the axial rotation, while the divisions of our common instruments for measuring distances are sufficiently minute to indicate the expansion of the earth's circular gyration, caused by the to an increased distance from the axis of rotation by animate exertion, and by mechanical force controlled by intellect."

A more important calculation is that concerning the retarding influence exerted upon the earth by the flow of rivers. Taking the surveys of the Mississippi by Generals Humphreys and Abbot, of the engineer corps of the army, as the basis of computation, Ericsson undertakes to show the extent of the retarding influence produced by the solid and sedimentary matter detached by the abrasion of rain-water, and afterward conveyed by the currents of rivers nearer the equator, thus farther from the axis of rotation. The Mississippi alone it appears retards the rotation of the earth $\frac{36}{1000000}$ of a second in a century. "Independent of the counteracting force of the tidal wave (hitherto greatly overestimated), the retarding energy called forth by the evaporation within the tropics and the consequent condensation and precipitation in the temperate zones, fully account for the retardation of the rotary velocity—twelve seconds in a century—inferred from the apparent acceleration of the moon's mean motion."

This barely indicates the character of Ericsson's investigations, in the course of which he has expended not only many years of labor, but large sums of money upon the apparatus needed for them. This apparatus, it is interesting to know, is to be presented to the Smithsonian Institute.

Let us return to Ericsson's practical works. Merely to enumerate them with the briefest possible description would occupy a volume. We have before us such a volume, one of 600 liberal quarto pages letter-press, and 67 pages of illustrations, half of which is occupied with the mere description of his engineering constructions since he came to the United States.* It is true that this includes the experimental apparatus to which we have referred, but it also includes a description of the various naval inventions and improvements in the machinery of war upon which Ericsson's later reputation is based, and which have made his name famous the world over.

Preliminary to these inventions, and even more important, was the introduction of the screw propeller, which we owe to Ericsson, and which has, during the past half-century, completely transformed the mercantile as well as the naval marine. The principle of the propeller is the substitution of oblique for direct action. Observation of the movement of birds and fishes had convinced Ericsson early in his career that the secret of rapid motion was in this oblique action, and it became his study to apply this conception to mechanics. His demonstrations pointed out that the reciprocating motion in the bird and fish must in machinery give place to a rotary motion better adapted to muscles and integuments of steel and iron. The construction of a model boat two feet long followed. To this two screw propellers revolving in contrary directions on a common center were attached. This boat was launched in the circular basin of a London bath-house and connected by a movable radial tube with a boiler placed by the side of the basin. The steam being turned on, the model screws revolved upon their common center, and the hoped-for result followed; the little craft sped around the circular basin at a speed which was calculated at six miles an hour. The problem was solved, and the inventor was justified in anticipating that transformation of the navies of the world which has followed. By adopting nature's method of producing locomotion by oblique action, he had not only secured a new means of propelling the vessels which navigate the seas, but had provided a means of locomotion for those aëronons of the "near future," which, in the fancy of our charming poet-philosopher Stedman, have already superseded the clumsy craft that swim the lower seas. Ericsson found, as Mr. Stedman undoubtedly expects to find and will find, that it is easier to satisfy one's self than it is to convince others of the value of original ideas. With what must have since seemed to him very like temerity, he attacked the enemy of prejudice in its stronghold, and endeavored to persuade the most potent lords of the British Admiralty to adopt his invention. He built a boat eight feet by forty, of three feet draught, armed with two propellers of five feet three inches diameter. These carried her through the water at the rate of ten miles an hour, or seven miles an hour towing a schooner of 140 tons burthen. Having with this vessel accomplished the feat of towing the American packet-ship *Toronto* at the rate of five miles an hour, Ericsson invited the Admiralty to a test which seemed conclusive. Steaming up to Somerset House with his little vessel, he took the Admiralty barge in tow and started ahead with her, to the wonder of the watermen,

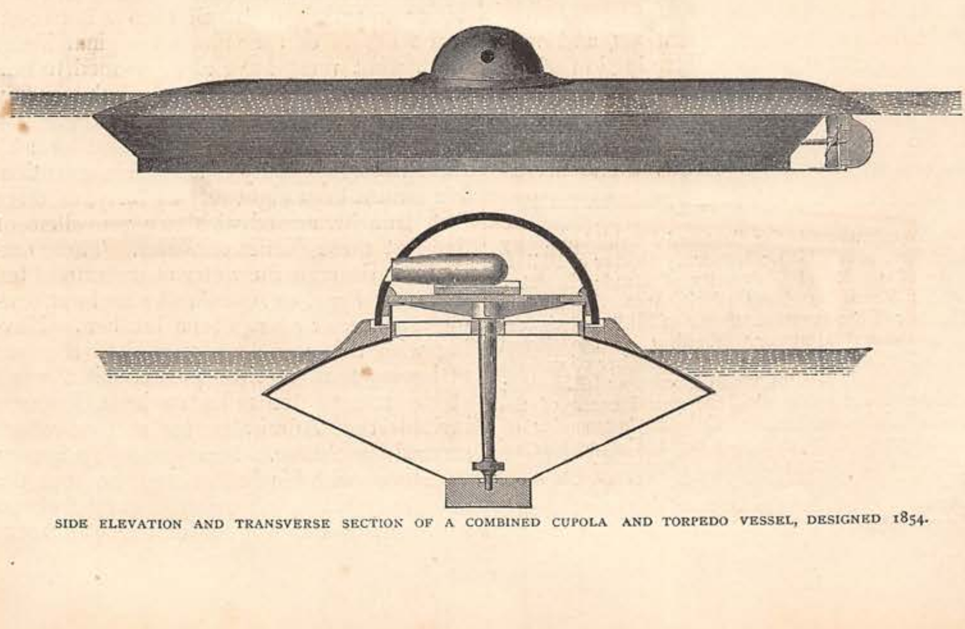
* Contributions to the Centennial Exhibition. By John Ericsson, LL.D.; Honorary Doctor of Philosophy of the Royal University of Lund; Member of the Royal Academy of Sciences, Stockholm; Member of the Royal Academy of Military Sciences of Sweden; Honorary Member of the Royal Scientific Society of Upsala, and member of various other scientific institutions in Europe and America; Knight Commander with the grand cross of the Order of Nordstjernan; Knight Commander of Dannevrog, first class; Knight Commander of Isabel la Catolica; Knight Commander of Sanct Olaf; and Knight of the Order of Vasa. New York: printed for the Author at the "Nation" Press. 1876.

PROPELLER VESSEL "FRANCIS B. OGDEN" TOWING THE ADMIRALTY BARGE ON THE THAMES, 1837.

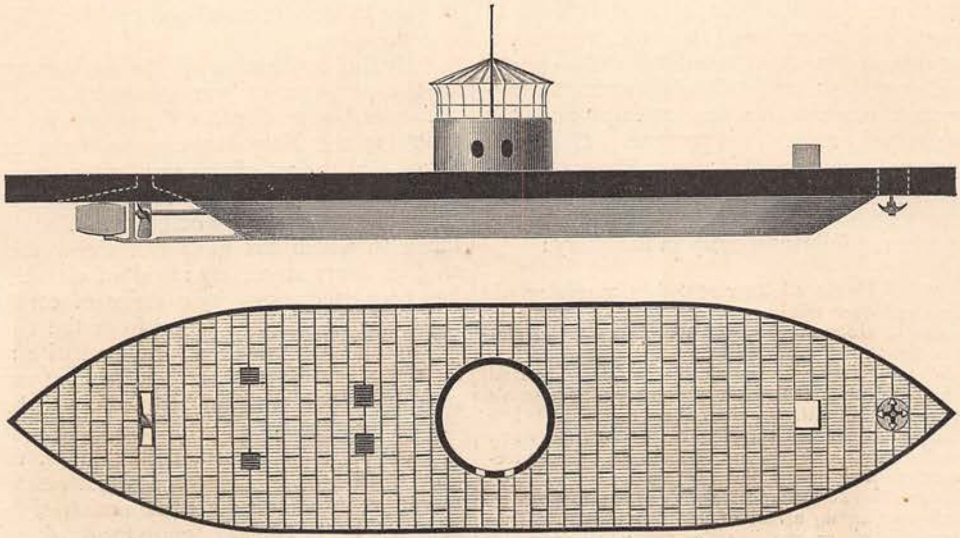
who could make nothing of the novel craft with no apparent means of propulsion. But the British Admiralty had sat on too many a promising invention to be so readily convinced by the mere evidence of their senses. With a consideration which did credit to their humanity, they forbore to crush the hopeful inventor with the proclamation of their wise conclusions. It was not until some time after that he learned incidentally, when the after-dinner conversation of a member of the Admiralty Board was repeated to him, that the verdict stood thus:

"Even if the propeller had the power of propelling a vessel, it would be found altogether useless in practice, because the power being applied to the stern, it would be absolutely impossible to make the vessel steer."

That bit of oracular wisdom cost England Ericsson and gave him to America! We were fortunate in having as our consul at Liverpool at that day, Mr. Francis B. Ogden, a pioneer in steam navigation on



SIDE ELEVATION AND TRANSVERSE SECTION OF A COMBINED CUPOLA AND TORPEDO VESSEL, DESIGNED 1854.

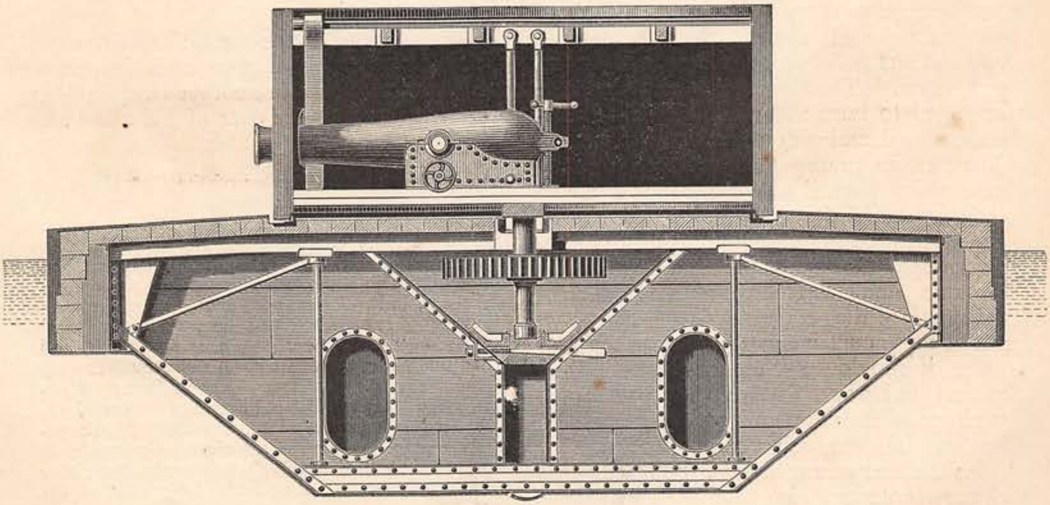


SIDE ELEVATION AND DECK PLAN OF THE "MONITOR."

the Ohio and Mississippi rivers. He appreciated the invention, and through him Ericsson was introduced to another American, Captain, afterward Commodore, Robert F. Stockton of the United States Navy. Captain Stockton was a naval officer, but he did not take his nautical wisdom in such "solid chunks" as the British Admiralty. Seeing with him was believing, and when he returned from a trip on Ericsson's boat, the *Francis B. Ogden*, he at once exclaimed, "I do not want the opinions of your scientific men; what I have seen this day satisfies me." Even before the vessel had completed her trip with Stockton on board, Ericsson received from him an order for two iron boats on the same plan as the *Ogden*. These boats Stockton's wealth enabled him to build at his own expense.

"We'll make your name ring on the Delaware as soon as we get the propeller there," declared the hearty sailor in an enthusiastic speech at the dinner following the day's excursion in the *Ogden*.

Confiding in Stockton's assurances that the United States would try the propeller on a large scale, Ericsson closed his engagement in England in 1839, and embarked for the United States. Determined to make good his assurances, Stockton besieged the



TRANSVERSE SECTION OF THE "MONITOR" THROUGH THE CENTER OF THE TURRET.

authorities at Washington for permission to build a steamer from Ericsson's designs and under his own superintendence. Two years' delay and a change of administration intervened between his first attempt and the accomplishment of his purpose. The vessel ordered was the *Princeton.* She was completed in 1844, and under the date of February 20th of that year, John Quincy Adams made the following entry in his diary:

"The House of Representatives yesterday adjourned over until to-morrow on the motion of Isaac E. Holmes, member from South Carolina, for the avowed purpose of enabling the members to visit the *Princeton*, a war steamer and sailing vessel combined, with the steam machinery of Ericsson's propellers, all within the hull of the vessel and below the water-line, and carrying twenty-four forty-two pound carronades and on her main deck two enormous wrought-iron cannon, with barrels of fourteen inches diameter, chargeable with 40 lbs. of powder, and discharging a ball of 225 lbs. weight. This vessel, a gimcrack of sundry other inventions of Captain Stockton himself, was built under his directions, and is commanded by him. She was ordered round here to be exhibited to the President and heads of the executive departments, and to the members of both Houses of Congress, to fire their souls with patriotic ardor for a naval war."

From the launching of "this gimcrack of sundry inventions" dates modern naval warfare under steam; it was the beginning of a new era in the warfare of the ocean. It was a revolution of incalculable importance, and one that has changed the construction of the fleets of the whole world. The semicylindric engine of Ericsson's designing developed the power of corresponding British marine engines with one-eighth of their bulk, and this engine was placed with its boilers four feet below the water-line, out of the way of shot and shell, against which the engines and boilers of foreign steamers had no protection. The furnaces and flues were arranged to burn anthracite as well as bituminous coal, and with a great saving of fuel. A telescopic smoke-stack replaced the tall pipe which formed so conspicuous a target for shot and shell, and which could not be carried away without deranging the draught. Centrifugal blowers in the hold, worked by separate small engines, secured sufficient draught to the engines of the *Princeton.* All of these contrivances as well as the propeller, it should be remembered, were then radical and novel features in a war vessel, familiar as they are now to every one who has been aboard such a ship.

As the first steamship ever built with machinery protected from shot by being placed below the water-line, the *Princeton* was the pioneer in modern naval construction. Nor was this all:

"By the application of the various arts to the purposes of war on board of the *Princeton*," says Captain Stockton, in his report to the Navy Department, "it is believed that the art of gunnery for sea-service has, for the first time, been reduced to something like mathematical certainty. The distance to which the guns can throw their shot at every necessary angle of elevation has been ascertained by a series of careful experiments. The distance from the ship to any object is readily ascertained with an instrument on board, contrived for that purpose, by an observation which it requires but an instant to make, and by inspection without calculation. By self-acting locks, the guns can be fired accurately at the necessary elevation, no matter what the motion of the ship may be." The self-acting lock, referred to by Captain Stockton, was offered to the English in 1828, but was employed for the first time on the *Princeton*, and has since been in common use on naval vessels. The committee of the American Institute said of the *Princeton:*

"Your committee take leave to present the *Princeton* as every way worthy the highest honors of the Institute. She is a sublime conception, most successfully realized,—an effort of genius skillfully executed,—a grand unique combination, honorable to the country, as creditable to all engaged upon her. Nothing in the history of mechanics surpasses the inventive genius of Captain Ericsson, unless it be the moral daring of Captain Stockton, in the adoption of so many novelties at one time."

The sad story of the public exhibition of the *Princeton* at Washington, after a successful trial-trip, is told in another entry in Mr. Adams's diary, under date of February 28, 1844.

"I went into the chamber of the Committee of Manufactures, and wrote there till six. Dined with Mr. Grinnell and Mr. Winthrop; Mr. Pakenham (the new British minister), and his secretary, Mr. Bidwell, were there. While we were at dinner, John Barney burst into the chamber, rushed up to General Scott, and told him, with groans, that the President wished to see him; that the great gun on board the *Princeton*, the 'Peace-maker,' had burst, and killed the Secretary of State, Upshur, the Secretary of the Navy, T. W. Gilmer, Captain Beverly Kennon, Virgil Maxey, a Colonel Gardiner of New York, and a colored servant of the President, and desperately wounded several of the crew. General Scott soon left the table; Mr. Webster shortly after; also Senator Bayard. I came home before ten in the evening.

"29th.—At the House, immediately after the reading of the journal, a message was received from the President announcing the lamentable catastrophe of yesterday, bewailing the loss of his two secretaries, with others, and hoping that Congress will not be discouraged by this accident from going on to build more and larger war-steamers than the *Princeton.*"

So tragic an introduction was not needed to direct public attention to the *Princeton.* As Senator Mallory, of Florida, said from his seat in Congress in May, 1858, "This vessel is the foundation of our present steam marine,—is the foundation of the steam marine of the whole world." Ericsson had placed the United States at the head of naval powers in the application of steam power to warfare. What was the reward a grateful country bestowed upon him for this service? He had made the experiment of the *Princeton* at a great cost to himself, and two years of concentrated effort had been devoted to the service of the government. For his time, labor, and necessary expenditures he rendered a modest bill of $15,000, leaving the question of what—if anything—should be charged for his patent rights, entirely to the discretion and generosity of the government.

This bill was paid at once, of course? Not at all. The present Congress is not the originator of those peculiar economies which consist in making use of sovereign power to treat just claims with sovereign contempt. Ericsson's bill was refused payment by the Navy Department, as was perhaps unavoidable, because of its limited discretion. He went to Congress; a dozen years passed without the slightest progress toward payment. A Court of Claims was at length established, and before this he finally obtained a hearing. A unanimous decree was rendered in his favor by the three judges, Gilchrist, Scarborough, and Blackford. From the Court of Claims, his account was returned to Congress for the passage of the necessary appropriation; there it has ever since remained. Not even the brilliant services which Captain Ericsson has rendered the country while this claim has been pending, have been able to secure its payment. He is an engineer, but not a lobbyist; and this tells the story of his disappointment. Were there any dispute as to the validity of the claim, there might be some show of justice or reason in the delay; but there is none. The American Congress will not appropriate the money to pay it, and that is all. It is said to be the nature of republics to be ungrateful; but must they also be dishonest?

It may be as well to dispose here of the disagreeable subject of Ericsson's treatment by the government, by adding that, for the inestimable service rendered it by over-persuading it to accept the *Monitor*, he has been similarly rewarded. Fifty thousand dollars could be found to pay for some worthless invention which it was supposed might be made use of on the monitors; but not a dollar has ever gone to the designer of the vessel itself. The only pecuniary recognition of his services was in giving him a contract to build six of a fleet of monitors at a price which compelled the contractors for the other vessels of the same class to go to Congress for relief.

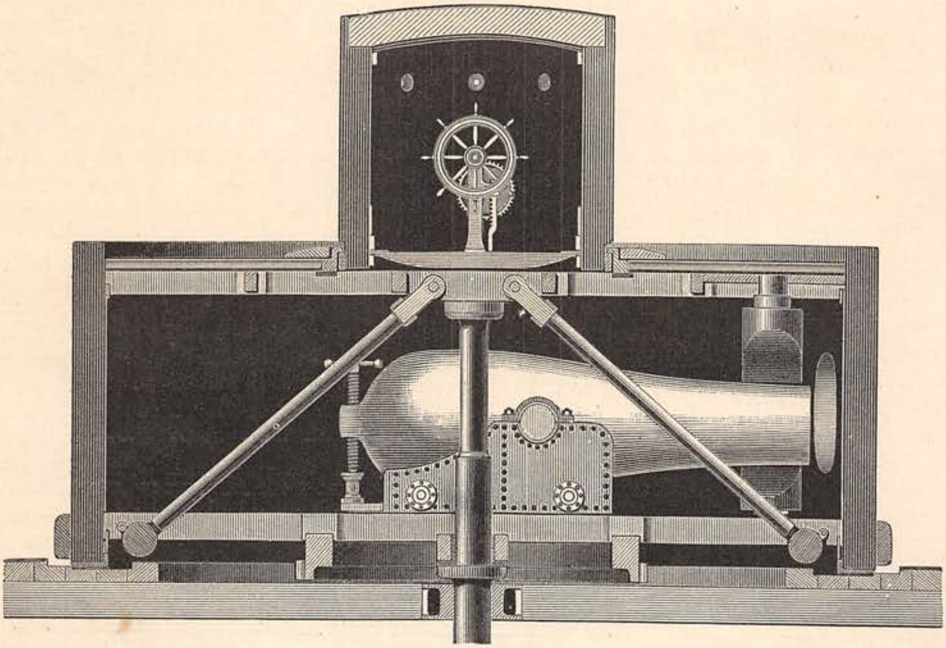
Whether or not Ericsson can, in a strict sense, have been said to have "invented" the screw, which was first introduced into naval constructions by the *Princeton*, there can be no question of the truth of the remark made by the London "Mechanics' Magazine," twelve years ago, that "the undivided honors of having built the first practical screw steamer, the first screw war ship, the first cupola (turret) vessel, belong to John Ericsson. That the screw propeller has been applied to vessels of war is due to the lessons, or rather warnings, that were wafted over the Atlantic. About a year after the launching of the *Princeton*, we got our *Rattler*."

Various nationalities claim the honor of the invention of the screw. At Trieste and at Vienna stand statues erected to Joseph Ressel, on whose behalf the Austrians lay claim to the invention, and patents for some sort of a screw date back as far as 1794. The late "Commodore" Stevens, of New Jersey, is included among the claimants, he having, it is said by Professor Thurston, of the Stevens Institute of Technology, built and worked a propeller in Hoboken in 1812. Leaving the champions of these various aspirants to dispute among themselves, I assert that there can be no reasonable question that, for the practical introduction of the screw propeller as a means of locomotion, we are indebted to John Ericsson.

Ericsson's transfer to the United States was worth a fleet to us, not only at the time, but again, at a more critical period of our history, when he placed us once more in the van of naval progress. No American, from whichever side of the border line he viewed the contest, can forget that dramatic scene when the little *Monitor* made its first appearance in Hampton Roads, on the eighth of March, 1862. The incidents of that memorable contest, in which she took such timely part, have been too frequently told to be repeated here. There is a chapter of her preliminary history not so familiar. In the glamour of his final success, the story of Ericsson's endeavor to secure the adoption of his revolutionary idea for a war vessel was easily forgotten.

The suggestion of the *Monitor* was, as before stated, first made in a communication from Captain Ericsson to Napoleon III. This communication, dated "New York, Sept. 1854," contained a description of an iron-clad cupola vessel which was substantially the *Monitor* as finally built. This will be seen from the comparison of the designs which precede (pages 848, 849 and 852), the first representing the drawing sent to the emperor and the others monitors actually in the service of our government. That this novel suggestion for a war vessel did not escape the emperor's personal attention is shown by the letter of acknowledgment from General Favre, who wrote: "The emperor has himself examined with the greatest care the new system of naval attack which you have communicated to him. *S. M.* charges me with the honor of informing you that he has found your ideas very ingenious and worthy of the celebrated name of their author."

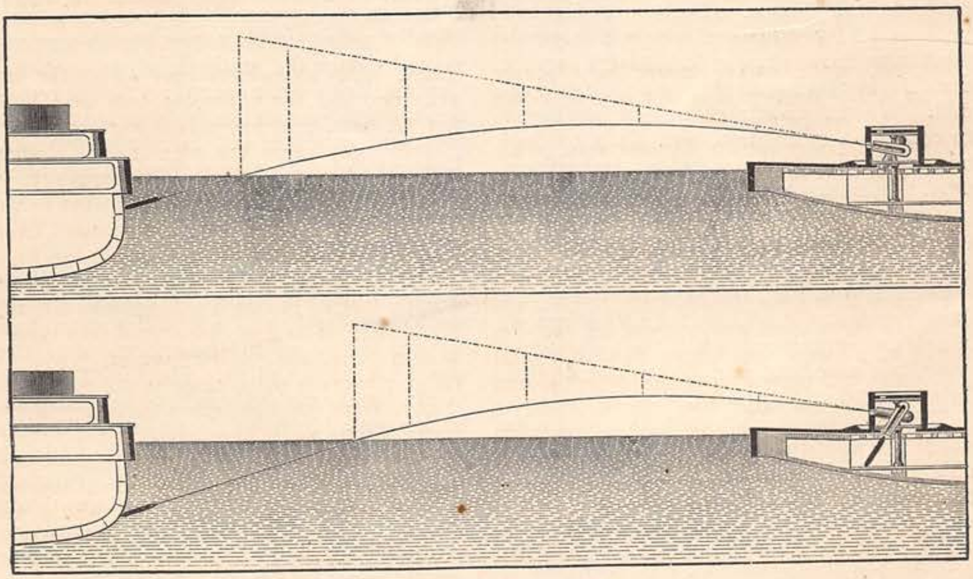
The new system of naval attack referred to here included not only the *Monitor*, but also movable torpedoes and a shell not subject to any rotation in the direction of its course, and so contrived as to explode with "infallible certainty at the instant of contact." These latter ideas have only within the last year reached their development and have not yet been tested in actual warfare.



TRANSVERSE SECTION OF PILOT-HOUSE AND TURRET. "PASSAIC" CLASS OF MONITORS.

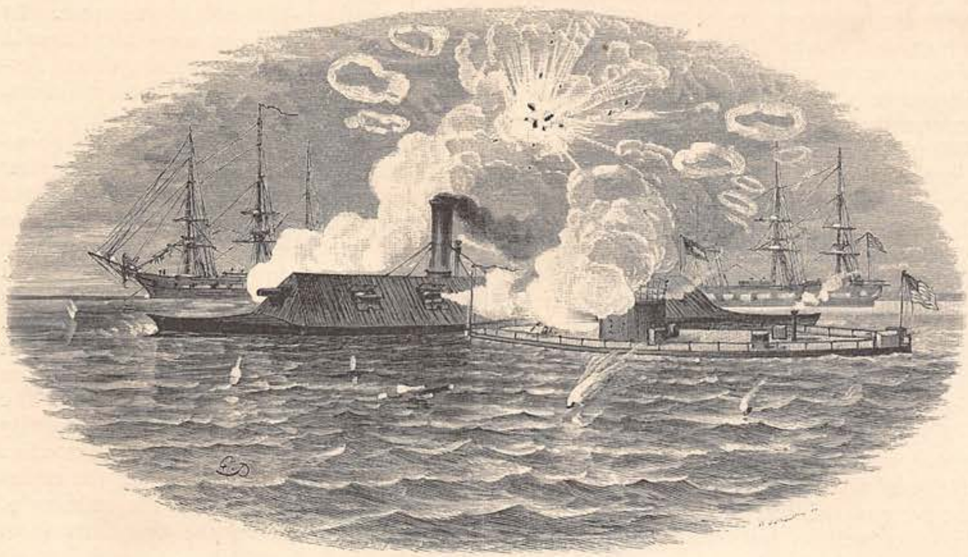
For eight years the idea of the *Monitor* awaited its opportunity. That opportunity came when the necessities of war led to the organization at the Navy Department of a board to determine upon designs for iron-clads. This board consisted of Commodores Joseph Smith, Hiram Paulding and Charles H. Davis. The last survivor of this board, Hiram Paulding, has died within the year. Of this board Commodore Smith was president. With his previous experience of the waste of time and patience required to accomplish anything at Washington, Captain Ericsson, who is not, it must be said, like the man Moses, "exceeding meek," would not himself go to the capital to secure attention to his ideas. There were, associated with him, three men of practical experience, great energy and wealth, who had become interested in the *Monitor* and were determined that it should have a trial. One of these was Mr. C. S. Bushnell, of Connecticut. He went to Washington, but failed in the attempt to persuade the iron-clad board that the designer of the *Princeton* was worthy of a hearing. Nothing remained except to induce Ericsson to visit Washington in person and plead his own cause, with that rude but forcible eloquence which has seldom failed him in an emergency. To move him was only less difficult than to convince the Navy Department without him. At last a subterfuge was adopted. Ericsson was given to understand that Mr. Bushnell's reception at Washington had been satisfactory and that nothing remained but for him to go on and complete the details of a contract for one of his vessels. Presenting himself before the board, what was his astonishment to find that he was not only an unexpected but apparently an unwelcome visitor. It was evident that the board were asking themselves what could have brought him there. He was not left long in doubt as to the meaning of this reception. To his indignation, as well as his astonishment, he was informed that the plan of a vessel submitted by him had already been rejected. The first impulse was to withdraw at once. Mastering his anger, however, he stopped to inquire the reason for the determination of the board. The vessel had not sufficient stability, Commodore Smith explained; in fact, it would upset and place her crew in the inconvenient and undesirable position of submarine divers. Now if there is anything which especially distinguishes the *Monitor*, with its low free-board, it is the peculiarity which it has in common with the raft it resembles—its inability to upset. In a most earnest and lucid argument, Captain Ericsson proceeded to explain this. Perceiving that his explanation had its effect, and his blood being well warmed by this time, he ended by declaring to the board with great earnestness: "Gentlemen, after what I have said, I consider it to be your duty to the country to give me an order to build the vessel before I leave this room."

Withdrawing to one corner, the board consulted together and invited Captain Ericsson to call again at one o'clock. Promptly at the hour named he appeared at the Navy Department. In the board-room he found Commodore Paulding alone. The commodore received him in the most friendly manner, invited him into his private office and asked that he would repeat the explanation of the morning as to the stability of the vessel. Between the two interviews, Ericsson had found time to make at his hotel a diagram presenting the question of stability in a form easily understood. With this diagram, he repeated his previous demonstration. Commodore, afterward Admiral, Paulding was thoroughly convinced, and with a frankness which did him great credit, said: "Sir, I have learnt more about the stability of a vessel from what you have now said than all I knew before."



NEW SYSTEM OF NAVAL ATTACK.

This interview ended with a request to call again at three o'clock. Calling at three,



FIGHT BETWEEN THE "MONITOR" AND THE "MERRIMACK" IN HAMPTON ROADS, MARCH 9, 1862.

Ericsson was at once invited to pass into the room of Secretary Welles. Here, without farther parley, the secretary informed him that the board now reported favorably upon his plan of a vessel, and wished him to return to New York and commence work upon it at once. The contract would be sent on for signature. Before this contract was received, the keel-plates for the first *Monitor* had passed through the rolling-mill. When the contract came, it was found to contain a stipulation that Ericsson had not expected. If the vessel proved vulnerable, the money advanced by the Navy Department from time to time was to be refunded. Such a guarantee was, perhaps, needed to restrain within limits too enthusiastic inventors, but it was certainly a hard condition, and one which Ericsson, after his experience with the *Princeton*, would not have been disposed to accept, had he known of it in advance.

Thus it happened that the vessel which saved the honor of the government, perhaps changed the issue of the war, belonged, not to the government, but to a private individual, and one who, patriotism apart, had good reason to feel anything but well-disposed toward that government. The last installment of money had not been paid on the *Monitor* when she fought her battle with the *Merrimack;* and had this vessel, hastily put together in one hundred days, failed to stand the crucial test to which she was on the instant hurried, not only would this last payment have been withheld but the payments previously made would also have been demanded back.

The spirit shown by Captain Ericsson under these circumstances was displayed in his reply to the resolutions of the New York Chamber of Commerce. These resolutions asked "such suitable return for his services as will evince the gratitude of the nation." Captain Ericsson answered: "All the remuneration I desire for the *Monitor* I get out of the construction of it. It is all-sufficient." The grateful nation took him at his word and saved its money to expend on bounty-jumpers and shoddy contractors who were not so easily satisfied.

The results obtained in that contest in Hampton Roads would, as Captain Ericsson contends, have been still greater had his suggestion as to the armament of the vessel been listened to. He urged that he should be allowed to build twelve-inch guns for her instead of the eleven-inch. With a smile of superior knowledge he was told that larger guns were not needed. He asked that he might be allowed to use thirty pounds of powder instead of the service charge of fifteen pounds, but he could not obtain the consent of the Chief of Ordnance, Captain Wise. Thus the *Merrimack* might, as he thinks, have been sunk side by side with the *Cumberland* with a single well-directed shot from a gun of heavier caliber fired with a maximum charge of powder. It is to be remembered, however, that the possibilities of heavy ordnance were only then beginning to be understood and are yet in process of development. At all events, the *Merrimack* was sufficiently damaged to have no further relish for an encounter with the *Monitor*. She never ventured on another assault and soon after ended her days less nobly than she might have done by becoming a *felo de se*.

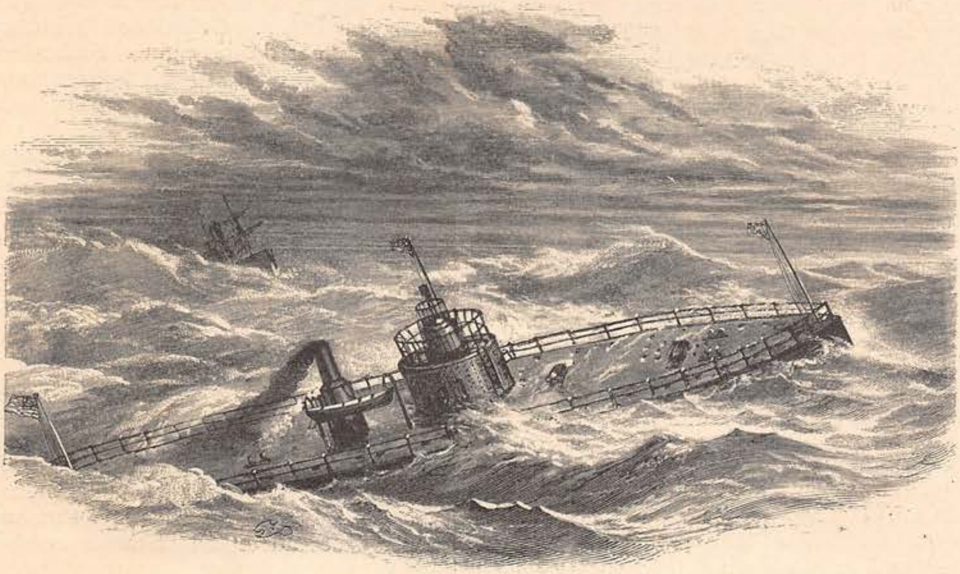
The monitors were speedily adopted by Ericsson's native country, Sweden, by Norway, and by Russia. England, with stubborn incredulity, long refused to believe that there was anything worthy of acceptance in this latest Yankee notion. It was not until the double-turreted monitor *Miantonomah* presented herself in English waters, in the summer of 1866,—more than four years after the appearance of the original *Monitor* in Hampton Roads,—that British public opinion finally yielded. Then something like a panic seized upon it. "The plain truth is," exclaimed the "Times," "the United States alone, among the nations of the earth, have an iron-clad fleet worthy of the name." The appearance of the *Miantonomah* was described "as a portentous spectacle." "Round the fearful invention," as the unhappy Englishmen were told, "were moored scores of big ships, forming a considerable portion of the navy of that great maritime power, and there was not one of them that the foreigner could not have sent to the bottom in five minutes, had his mind not been peaceful. There was not one of these big ships that could have avenged the loss of its companions, or saved itself from a like fate. In fact, the wolf was in the fold, and the whole flock was at its mercy."

An English naval officer, Captain Cowper Coles, sought to establish a claim for priority of invention over Ericsson, asserting that his experience in the Baltic and Black seas, in 1855, during the Crimean war, had suggested to him the idea of protecting guns by a stationary shield or cupola, of which he had a rough model made at the time. But Ericsson's letter to the Emperor Napoleon, in which the plan of the *Monitor* was presented in detail, was dated "September, 1854," and that plan included something more than a stationary shield or cupola—the idea of a vessel with sides protected against shot by being submerged in the water, thus securing protection and buoyancy at once. After much persistence, Captain Coles succeeded in persuading the Admiralty to build a vessel on his plan. She was finished, manned, equipped, and sent to sea with her designer on board. Off Cape Finisterre, Spain, she upset on the night of September 6th, 1870, and went to the bottom with Captain Coles and a British crew of over 500 men.

Thus ended the last chapter in the discussion between Cowper Coles and John Ericsson as to the comparative value of their two systems. Aside from the constructor's fatal error as to stability, which cost England the lives of so many seamen, Cowper Coles's high-side iron-clad was a feeble groping and experimental step in an old path. The *Monitor*, on the contrary, leaped with one bound wholly beyond the beaten track of naval architecture, and in so doing vaulted the obstacles which beset the path of the old model. It was at once audacious and revolutionary in its design, and admitted of no compromise or tinkering, such as Cowper Coles attempted at the cost of his life.

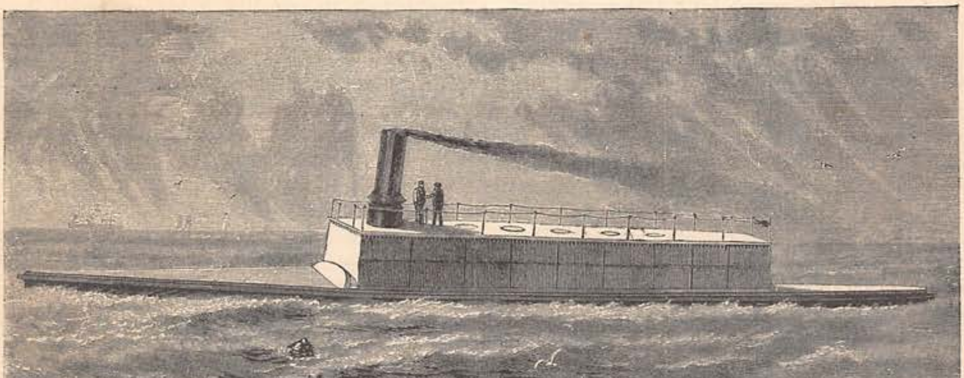
At present, Captain Ericsson's time is chiefly devoted to the introduction of his new system of submarine attack. Having shown the naval world how to build armored vessels uniting maximum resistance with maximum stability afloat, he is now proposing to show them how to abolish iron-clads altogether. Indeed, it is a growing conviction with many other thoughtful observers that the day of iron-clads is fast passing; that the increasing resources of attack will have much the same effect upon armored vessels that the introduction of gunpowder had upon armored men. Again Captain Ericsson leads the advance, and with his torpedo, *Destroyer*, emphasizes the warning he gave to foreign navies with his *Monitor*, which, as he stated at the time, in explanation of the name, would be to the Lords of the Admiralty a monitor "suggesting doubts as to the propriety of completing their four steel ships, at three and a half millions apiece."

The *Destroyer*, a vessel built at Captain Ericsson's own expense, costing about fifty thousand dollars, is now complete and ready for service. The object of its construction is to overcome the existing defect in movable torpedoes,—the difficulty of guiding them. It is this that has rendered the famous Whitehead torpedo, upon which England has expended so much money, practically worthless. On several occasions it has had opportunity to show its quality, notably during the Russo-Turkish war, and in an isolated contest last year between the English *Shah* and

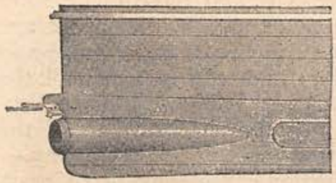


MONITOR "WEEHAWKEN" IN A STORM.

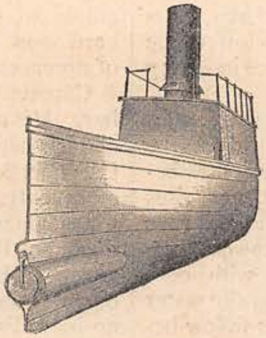
the Peruvian *Huascar*, in South American waters. The fact that the much-vaunted Whitehead has thus far accomplished nothing, is one not to be explained away by the admirers of this system of torpedo attack. Its fatal defects are that it cannot be turned from the direction in which it is once started, and that its propulsive force is so slight that light netting surrounding a vessel is sufficient to stop its progress. Its course is marked, too, by bubbles of air at the surface of the sea, which give warning of its approach, and enable a vessel to steer clear of it, as was done in the case of the *Huascar*, which escaped the attack of the Whitehead sent out by the *Shah*. The *Destroyer*, instead of being an automaton torpedo left to its own uncertain guidance, is a swift iron-clad vessel, manned and directed by a sufficient crew, and excelling in speed any of the heavy armored vessels afloat. It does not seek concealment, but trusts to its invulnerability and speed. Both ends are alike, so that, having discharged the torpedo, the *Destroyer* is able to steam away at full speed by simply reversing its engines. The torpedo with which it is provided has none of the internal mechanism that has proved so delicate and untrustworthy in other torpedoes. Ericsson's torpedo, in reality a submarine projectile, is discharged from the bow of the vessel by means of compressed



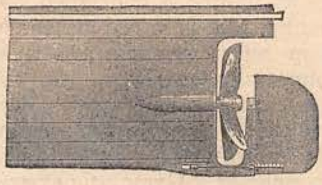
SIDE ELEVATION OF THE "DESTROYER" IN FIGHTING TRIM.



BOW OF THE "DESTROYER," THE TORPEDO TUBE OPEN FOR ATTACK.



EXTERNAL APPEARANCE, THE TORPEDO TUBE BEING CLOSED.



SIDE ELEVATION OF THE STERN, SHOWING PROPELLER, RUDDER AND ONE OF THE HYDRAULIC STEERING CYLINDERS.

air. As it weighs 1,400 pounds and has an initial velocity of 164 knots an hour, its momentum is such that it is not easy to see what outer defenses can protect a vessel from being hit by the projectile torpedo. The nozzle of the projectile carries a heavy charge of dynamite, to be exploded by concussion, but so arranged that it requires the resistance of a ship's side to fire the charge. The *Destroyer* is yet in the stage of experiment, except with its designer, who regards it as in all respects *un fait accompli.* Its preliminary trials for speed have been very satisfactory, so far as the intention of the designer is concerned, which was to produce a vessel excelling in speed existing iron-clads. The unimpaired vigor of body and mind which distinguishes Captain Ericsson at the age of seventy-six is illustrated by the fact that all the working drawings of the *Destroyer* have been made, as is customary with him, by his own hand, his assistant merely tracing these drawings for the use of the workman.

When we remember that John Ericsson was a competitor with Stephenson in that far-away period when the steam locomotive made its first essays in England, we realize the impossibility of giving any adequate idea of such a career as his within the limits of a magazine article. No more has been undertaken here than the briefest possible description of works the value and importance of which are most readily understood. Although these works are usually referred to as inventions, it should be remembered that Captain Ericsson objects, and with reason, to the title of inventor, a designation more properly belonging to men endowed with fertile genius but lacking rudimental knowledge, and in most cases ignorant of the first principle of mechanics. Ericsson's knowledge, on the contrary, embraces the entire range of mechanical philosophy. He is also a profound geometrician, and possesses greater practical experience as a mechanical constructor than any living man. In classical signification, as well as in popular use, the word inventor conveys too, the idea of merely coming upon a thing, of happy conceit rather than of rigid reasoning from cause to effect. Ericsson's results, on the contrary, have been accomplished through a mastery of physical science which entitles him to rank as unquestionably the foremost engineer of our time. Let who can dispute with him this title!

Of the purely personal history of a man like Captain Ericsson who devotes to labor all the time not occupied with eating and sleeping, little is to be told. No one could more completely identify himself with his works; and this man, whose name is intimately associated with the world's most vital material interests, is as far removed from its every-day concerns as the hermit in his cell. His whole thought is absorbed with his scientific and mechanical studies, and he never leaves the roomy old house in Beach street, New York, which is at once his dormitory and his work-shop, except it be for exercise or on some imperative errand of business. Social recreation he has none. He accepts no invitations and gives none; his only visitors are those who have business with him. His time is divided according to rigid rules, which make the most of the twenty-four hours. Among the machinery which he has studied to some purpose is that through which his mental operations are conducted, and he has, as we have said, shown himself able to devote himself to sedentary work for twelve hours a day for three hundred and sixty-five days in the year, for certainly thirty years together, with scarcely the loss of a day. This is explained by the fact that, since he was forty years of age, Captain Ericsson has followed the most exacting rules of temperance in eating as well as in drinking.

One day with him is like another, so far as its routine is concerned, and this is the routine: he is called at twenty minutes before seven, summer and winter, and rises punctually at seven. On rising, he rubs his skin thoroughly with dry towels, previous to a vigorous scouring with cold water, crushed ice being added to the water in summer. Gymnastic exercises follow before dressing. At nine o'clock a frugal breakfast is taken, consisting of eggs, tea, and coarse brown bread. At half past four he dines, the dinner never varying from chops or steak, a few vegetables, and brown bread and tea again. With the exception of tea, his only beverage is ice-water, and this is partaken of without stint. Tobacco is never touched in any form, and no dissipation whatever in the way of eating and drinking is allowed under any circumstances to vary this anchorite routine.

The hours from dinner-time until ten at night are usually devoted to work, and from ten until twelve Captain Ericsson seeks exercise in the open air. During working hours his time is divided irregularly between the drawing-table and the writing-desk. The day's labors conclude with a record of its events in a diary, which has one page devoted to each day, never more and never less. This diary is written chiefly in Swedish, and has now reached its fifty-seventh volume, amounting altogether to over 14,000 pages, indicating a period of about thirty-nine years. Not a day has been omitted in this period, excepting about twenty days during the latter part of 1856, when Captain Ericsson met with an accident which deprived him of a finger on his right hand, crushed by machinery. It may be added that his bedroom windows are never wholly closed, even during the severest weather, he having mathematically demonstrated for himself that direct communication should exist between the inner and the outer air, "to the extent of a sectional area of fifty square inches." The hall windows of his house are open, too, winter and summer, and none but open grate fires are allowed. Insomnia never troubles him, for he falls asleep as soon as his head touches the pillow. His appetite and digestion are always good, and he has not lost a meal in ten years. What an example to the men who imagine that it is hard work that is killing them is this career of unremitting industry!

Captain Ericsson is a widower and is childless. His family ties are through the children of his brother Nils, and those of his sister Caroline, Mrs. Odhner, who died at the age of seventy, leaving two sons, Emanuel and Claes Theodor; both of these sons took the degree of Doctor of Philosophy at the University of Upsala, the latter carrying off the highest honors of this celebrated university,—no light distinction considering that Upsala has 1,300 students, the *élite* of the Swedish youth. Claes Theodor Odhner is now professor of history in the University of Lund and has published several historical works, the latest of which has attracted much attention. Emanuel died several years ago.

Nils Ericsson, John's elder brother, although a powerful man, physically as well as mentally, died at the age of sixty-nine, from the effects of a severe surgical operation. He was ennobled at an early age, and in due time by royal favor became a baron. It is to his genius and enterprise that Sweden owes her system of state railroads, located with chief regard to strategical purposes, Nils Ericsson being colonel of engineers, as well as chief of the Swedish state railways. On the completion of the western branch of these railways the grand cross of the order of Vasa, set in diamonds, was presented to him by King Charles XV. The road on the eastern side of Sweden he did not live to see completed. Colonel Ericsson had three sons by his wife, Countess Wilhelmina Schwerin, John, Charles and Verner, and one daughter, Hedda, married to Count Axel Mörner. John and Charles entered the Swedish army at an early age, and the latter, led by a spirit of adventure, obtained leave of absence and went to Africa, joining a regiment of French Zouaves about embarking for Mexico. From Mexico he returned bearing the cross of the Legion of Honor and the scars of nine wounds. Soon after his return he was elected a member of the Swedish Diet, in which his father and brothers already occupied seats. The unusual spectacle was thus presented of a father and three sons of the Ericsson family being at one time members of the national legislature.

From this it would appear that the genius of John Ericsson is no abnormal growth, but the healthy product of a rare stock which has in him reached its best development.